Long Term Climatology of Precipitable Water From Space

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The availability of microwave measurements of water vapor from space makes the routine estimation of total precipitable water (P) over oceans a reality. Early estimates of P from the NIMBUS SMMR instrument demonstrated that realistic distributions of water vapor could be generated from simple algorithms. These algorithms can be applied to the DMSP SSM/I instrument and mean estimates of moisture can be made over the global ocean. Currently, the instrument characteristics and the orbital strategy prevent the use of these data sets for synoptic temporal and spatial scale resolution. Further, climatology based on SSM/I restrict observations to 1987 and into the future. Next generation systems, particularly those associated with EOS, may eliminate this resolution shortcoming. It would be scientifically advantageous to have a long term climatology available for comparison when the more comprehensive climatological microwave data become available.

The current work attempts to estimate P fields over oceanic areas for the period 1979 to present, based on available infrared observations, model analysis and radiative transfer models. The procedure is simple statistical regression. Ground truth is obtained primarily from available SMMR and SSM/I estimates. Prediction data include TOVS (polar orbiting) moisture channel brightness temperatures, OLR observations, and ECMWF model estimates. Preliminary calculations indicate that approximately 70% of SMMR P variance can be estimated based on satellite observations and the ECMWF analysis model of 1979 vintage. The same procedure, using a 1986 version of the ECMWF analysis model raised this predicted variance to 80%. Using more satellite observations and more complex algorithms could potentially improve P estimation further. The most serious shortcoming of this procedure is that, for each operational change of the ECMWF analysis system, a commensurate change in the perceived "climate" also occurs. Examination of the various analyses and data sets demonstrates that such a climatology, accurate at synoptic scales, is feasible.

The accompanying figures describe some of the data available. Table 1 shows the correlation between P estimators (OLR, TOVS 6.7 and 7.3 channels, and ECMWF P analyses) and the ground truth SMMR, and between each other. All estimators show positive skill and the shared variance between esti- mators (except the two TOVS channels) is small. Figure 1 shows a scatter diagram of ECMWF analysed P and SMMR estimated P, and a stratification of the observations according to synoptic system. Although the skill of the analysis is positive, it is restricted almost exclusively to the synoptic scale. When they data are stratified by system, their scatter within a system is almost circular, suggesting that the best predictor is the weather system mean; that is, climatology.

The satellite observations are incorporated to resolved further synoptic detail not captured by the operational analysis. Figure 2 shows two tropical conditions--a weather system called a tropical plume and a synoptically quiescent ITCZ--as viewed by TOVS, OLR and VAS 6.7 imagery. The composite data sets show both similarities and differences in system horizontal structure. Figure 3 intercompares SMMR and OLR estimates through a typical plume. The shortcomings of the satellite coverage are evident, as is the quality of the observations where they exist. Finally, Figure 4 intercompares TOVS infrared moisture structure (middle), with that estimated by a combination of ECMWF analysis and a radiative transfer model (computed as if a satellite "flew through the analysis"). The top panel displays a 1979 version of the model; the bottem, a 1986 version using the same data input. Shortcomings of both analyses are obvious, as is the improvement of the more modern analysis.

These data sets have the capability of inferring accurate moisture distributions when developed and compared judiciously with SMMR and SMM/I observations.

TABLE I.

Correlation of SMMR and other precipitable water estimates.

	TOVS 11	TOVS 12	OLR	ECMWF
SMMR	−.61	−.48	−.56	.70
TOVS 11	*	.89	.66	−.56
TOVS 12	*	*	.55°	−.44
OLR	*	*	*	−.44

FIGURE 1.
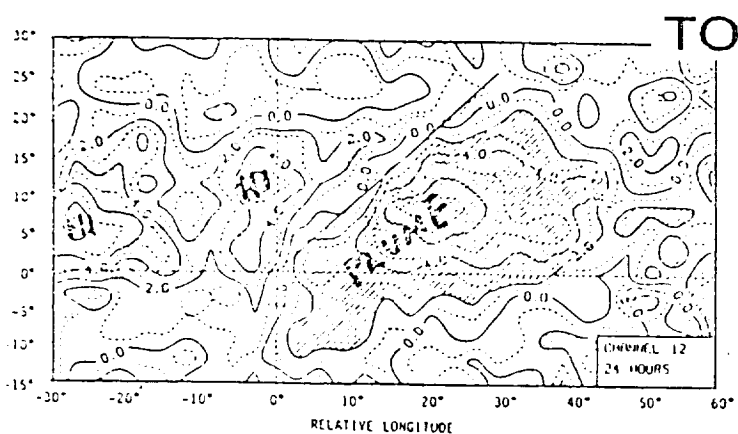
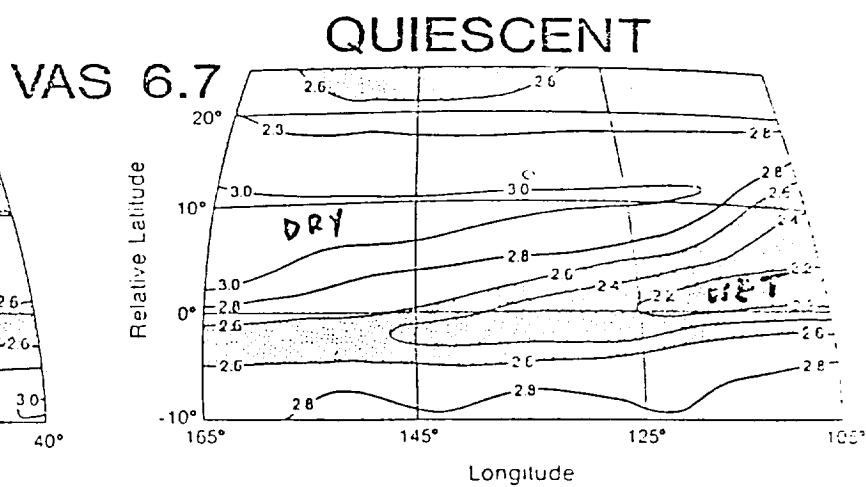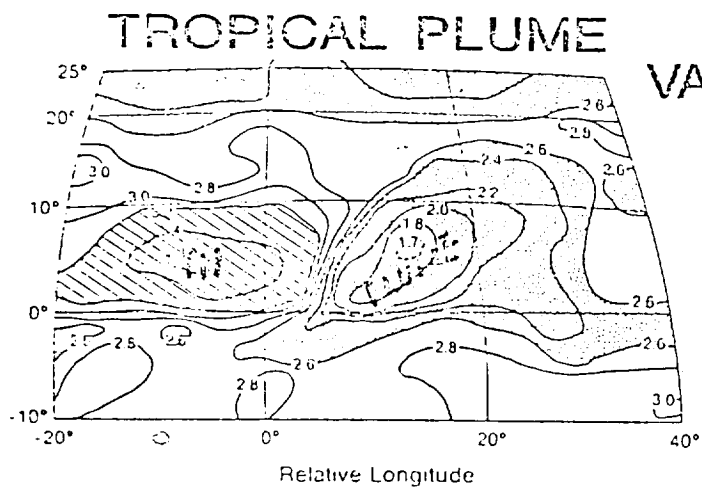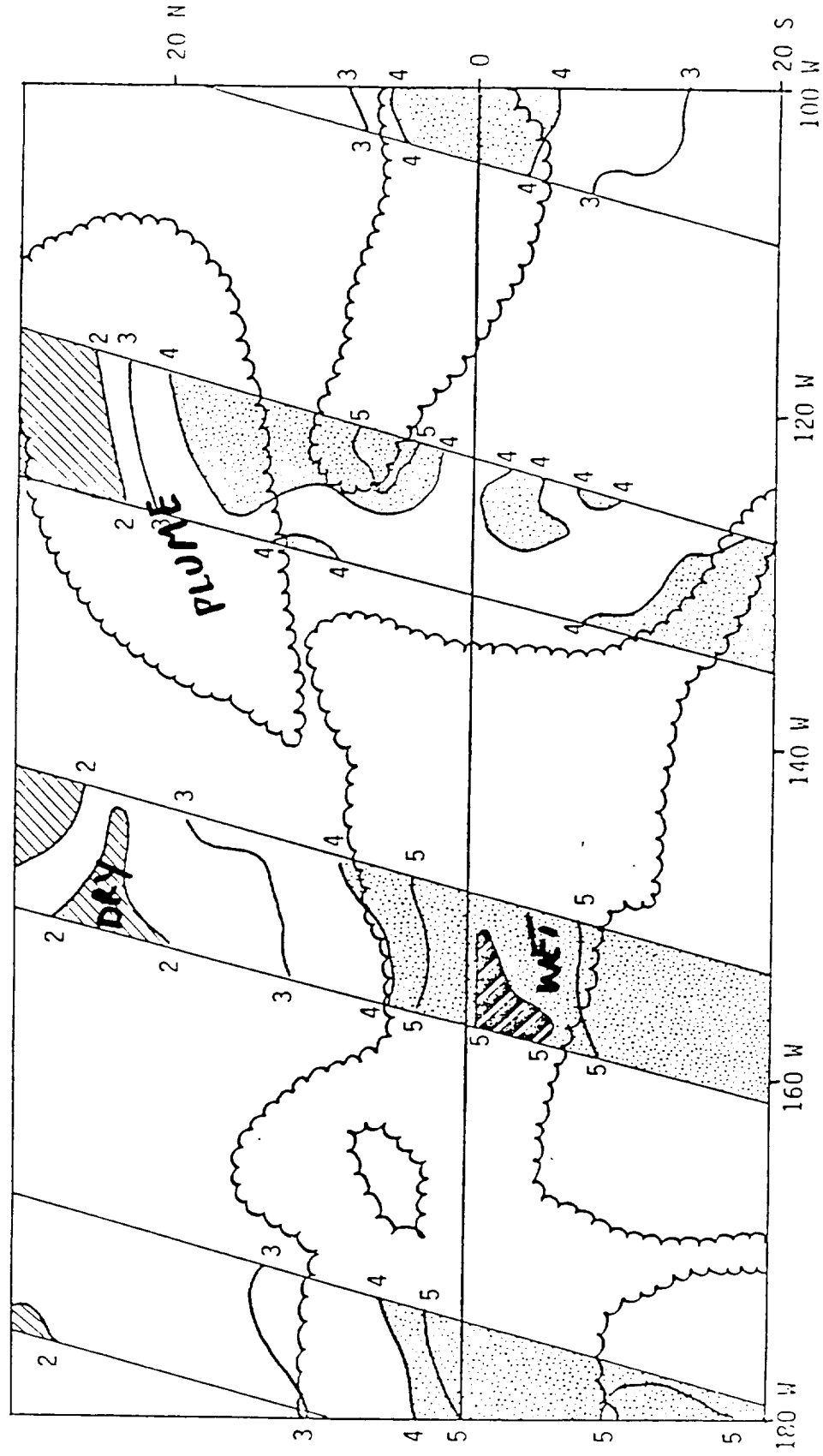## ECMWF/SMMR BY SYNOPTIC FEATURE
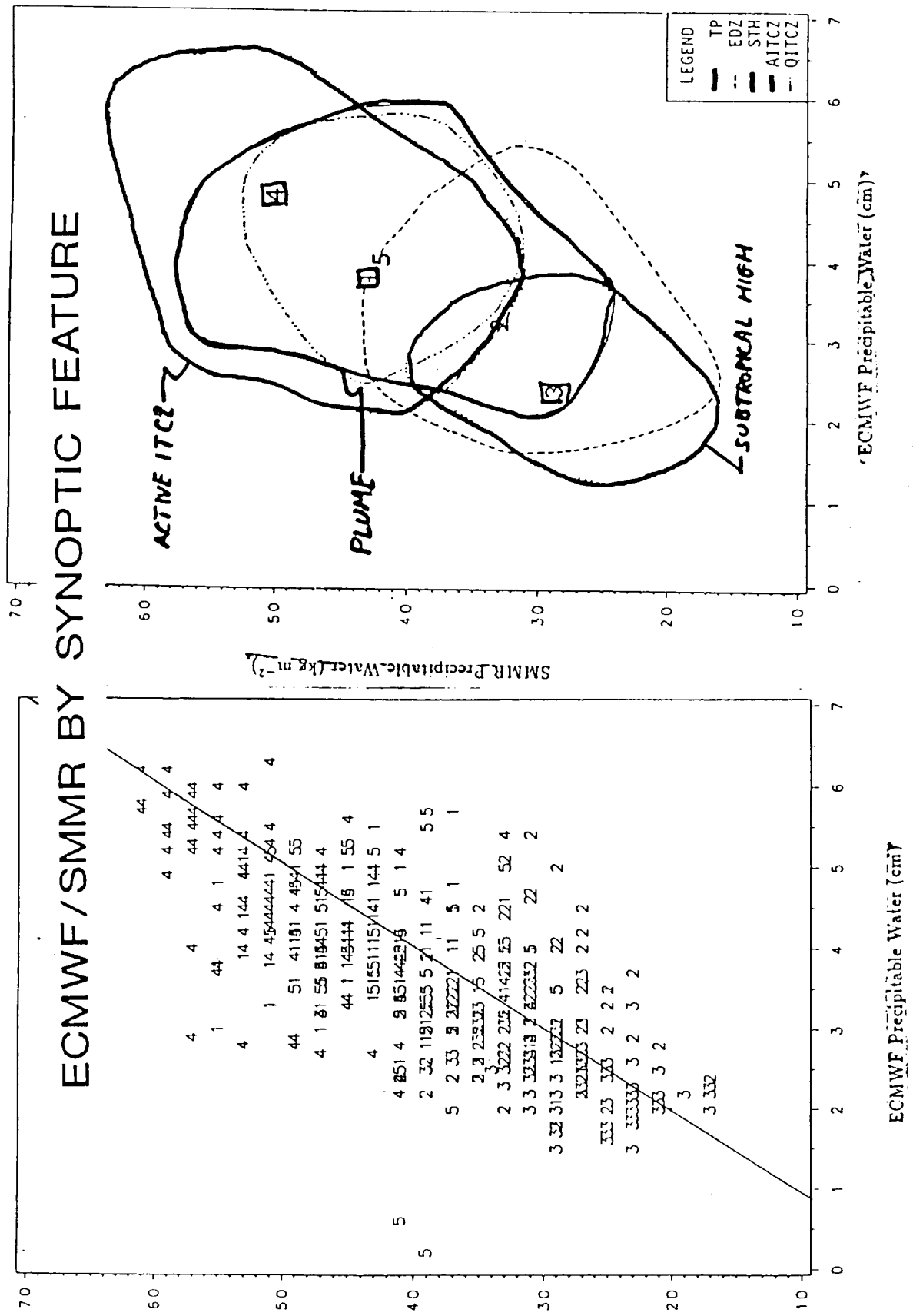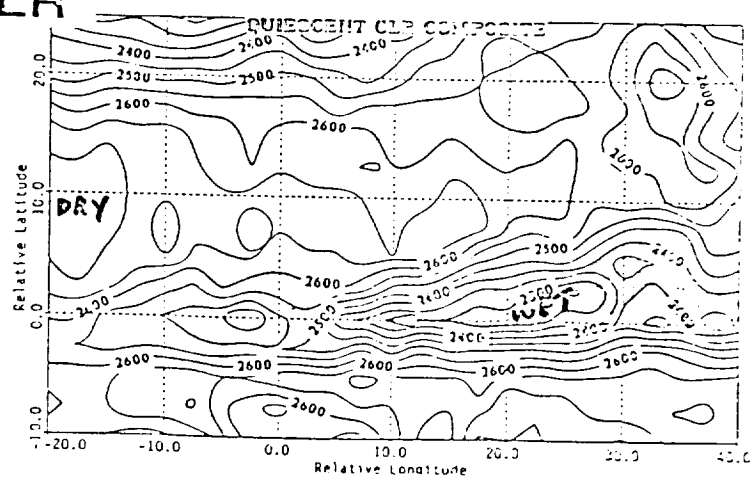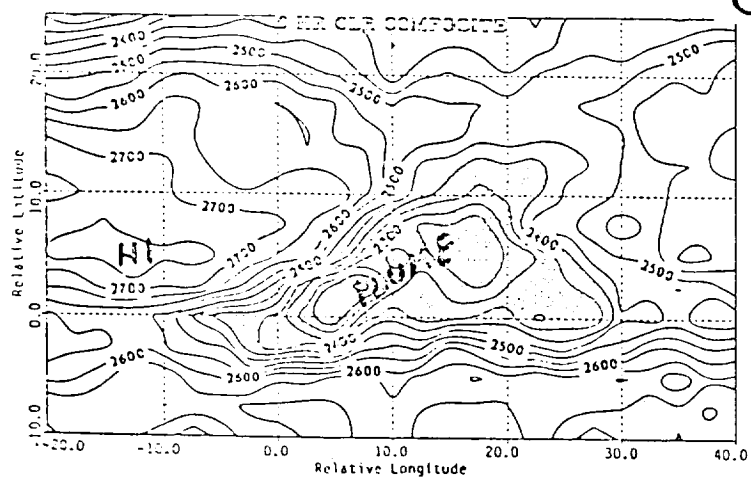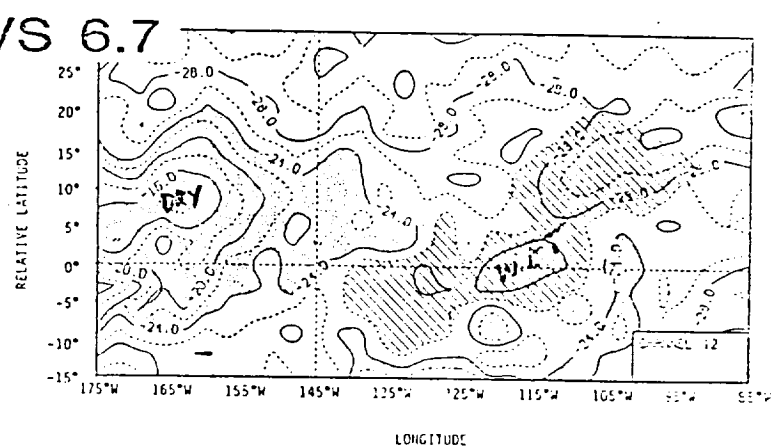
FIGURE 2.

FIGURE 3.

SMMR PRECIPITABLE WATER / CLOUDS

SMMR estimates of precipitable water (contoured in cm) from four consecutive SMMR passes. The SMMR passes are overlaid on a schematic of the 12 GMT GOES IR image for January 26, 1979. Stippling is moist; hatching is dry; dark hatching is contaminated by heavy precipitation; scalloped regions demarcate cloudy areas.